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CALIFORNIA DIVISION

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MODEL**TITLE** ANALYSIS OF A-12 ESCAPE SYSTEM

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INTRODUCTION

A study has been made to determine the most suitable escape system for the A-12 airplane. The various possibilities have been explored in detail from the points of view of requirements, reliability, weight, and operational suitability. This report presents the results of this study.

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SUMMARY

The possible escape systems for the A-12 airplane have been examined in detail. These possibilities include fuselage nose capsules, encapsulated seats, and rocket-catapult seats. The advantages and disadvantages of each type have been considered and their suitability discussed.

It has been determined that the most reliable, lightest, smallest and safest system which can satisfy the high and low level escape problems for the A-12 airplane consists of a full pressure suit and a rocket-catapult ejection seat.

The suit proposed is the David Clark MC-2, equipped with the MA-3 helmet. This combination has been developed for the X-15 program and has a demonstrated capability for airblast and temperature resistance far in excess of that required for the A-12. It should be noted that a pressure suit is a requirement independent of the ejection problem, since loss of cockpit pressure is a much more common difficulty than any trouble requiring abandoning the aircraft.

The seat proposed is the Lockheed upward ejection C-2 seat as used on the F-104. This seat is equipped with the XM-10 rocket catapult, and provides a vertical rise of 230 feet in static firing. A successful static recovery has been demonstrated using this seat, with a special chute deployment arrangement.

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PROBLEM STATEMENT

The A-12 airplane operates through a range of altitude from sea level to [REDACTED], at speeds up to [REDACTED] at altitude and at airspeeds up to 450 kts EAS. The ram temperatures during escape may be [REDACTED]. The mission's maximum flight velocity and altitude are programmed as shown in Figure 1.

In addition to the above escape environments, there is another condition which applies: The ability of the A-12 to complete its mission cannot be compromised; that is, minor malfunctions must be tolerable by the pilot. Any pilot environment-escape system which requires ejection because of a loss of cockpit pressure or a raising of cockpit temperature, for example, is obviously unacceptable. The escape system must be considered as part of the total pilot environment. He must be protected against any loss of cockpit pressure or temperature control without being forced to eject himself to stay alive.

From the above it follows that a pressure suit is a necessity, whatever the escape system might be. The so-called "shirt sleeve" cockpit is unrealistic. On the U-2 program to date, cockpit de-pressurization has occurred at altitude approximately 400 times. It is apparent that any escape system must protect the pilot against this much more likely occurrence.

Low altitude escape capability is considered at least as important as high, since a large proportion of ejections occur at such low altitudes.

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The F-104 experience supports this conclusion. Initially, the F-104 had a downward ejection seat since this type is better for high altitude ejection, and it was believed that the majority of ejections would occur high. Flight experience, however, showed that approximately 80% of ejection attempts were at low altitude and resulted in a high percentage of ejection attempt fatalities. As a result of this experience, all F-104s are being converted to upward ejection.

Ideally, an airplane should have a zero velocity, zero altitude ejection system, which would also function at all other velocities and altitudes. At present, no one has succeeded in achieving the zero velocity part of the low altitude end, although sled tests have shown safe ejections as low as 90 kts.

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DISCUSSION

The possible escape systems are:

1. Fuselage nose capsules.
2. Encapsulated seats.
3. Rocket-catapult seats.

These possibilities will be considered in order.

Fuselage Nose Capsules

A study was made of a nose capsule for the A-12. Lockheed's Preliminary Design Department has designed a fuselage nose capsule for the F-104 as part of an Air Force study. This design has progressed to a mockup stage, as shown in Figures 2 to 7.

As shown in the figures, this is an extremely elaborate and sophisticated design. Not clearly shown in the figures are the ballistic guillotines for severing control cables, electrical cabling, plumbing lines, air ducts, etc. It is estimated that this system increases the weight of the F-104 by about 1,500 pounds. It is also believed that such a complex system will have such a low degree of reliability that the pilot's safety has actually suffered. A study of a nose capsule for the A-12 is shown in Fig. 8.

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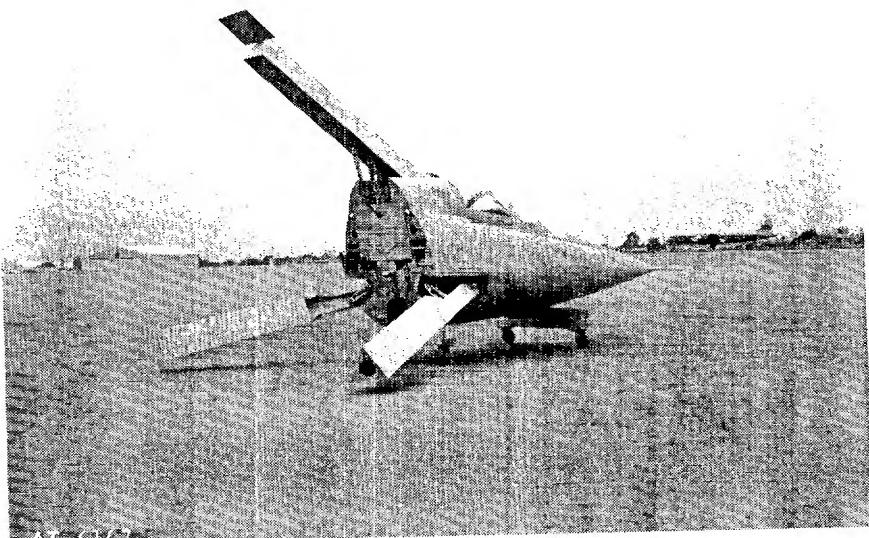


FIG. 1 REAR 3/4 VIEW

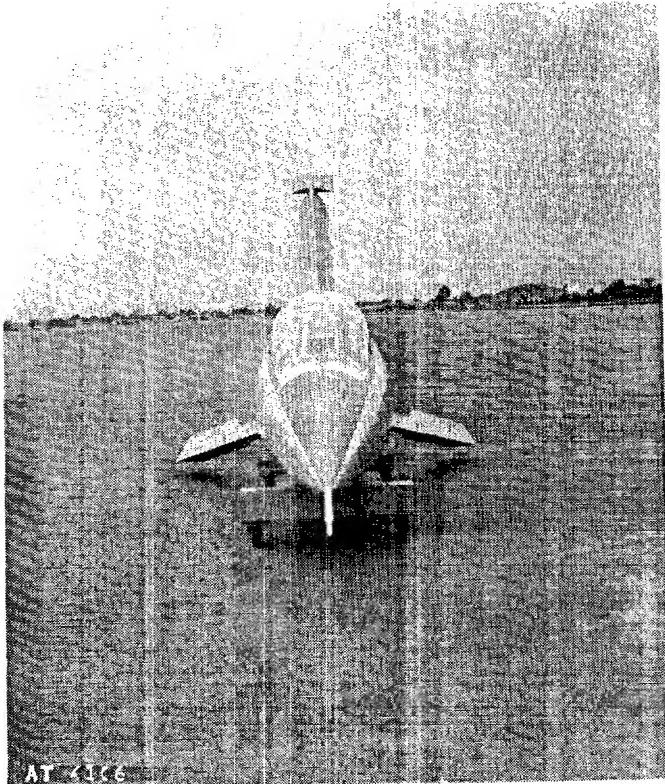


FIG. 2 FRONT VIEW

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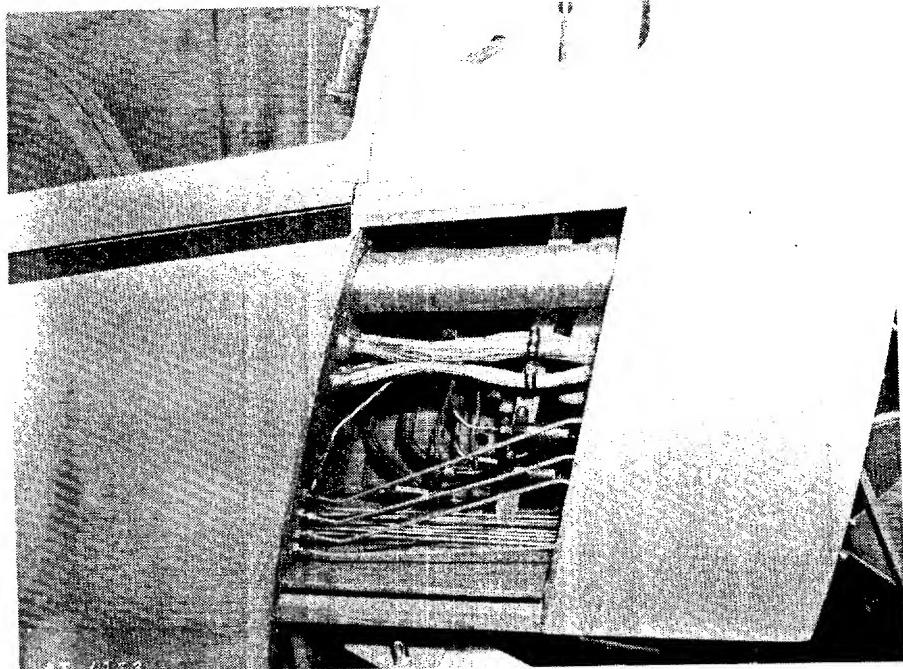


FIG. 5 LEFT SIDE VIEW SHOWING FUNCTIONAL LINES

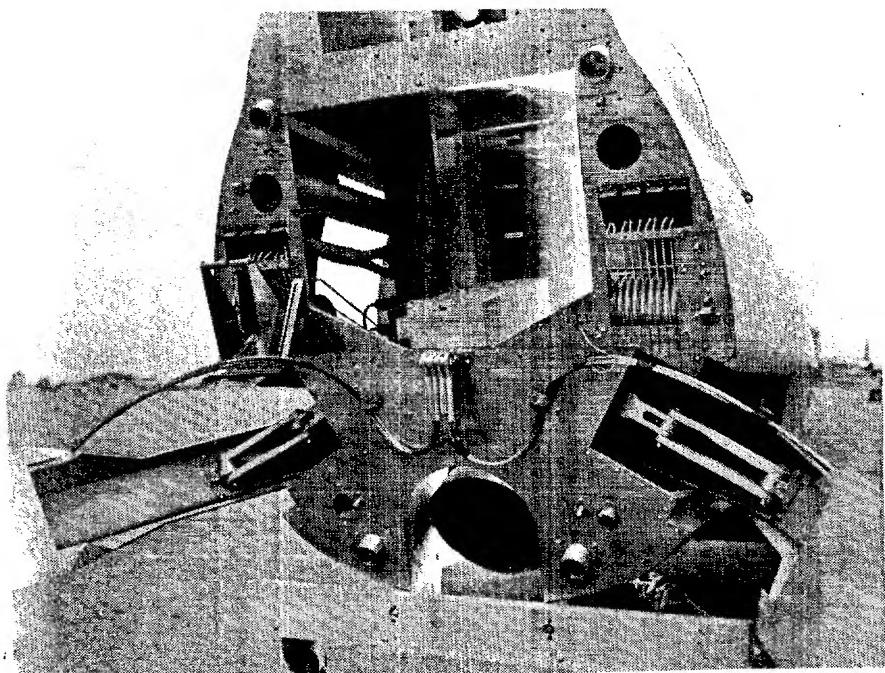


FIG. 6 REAR VIEW, PARACHUTE BOX REMOVED

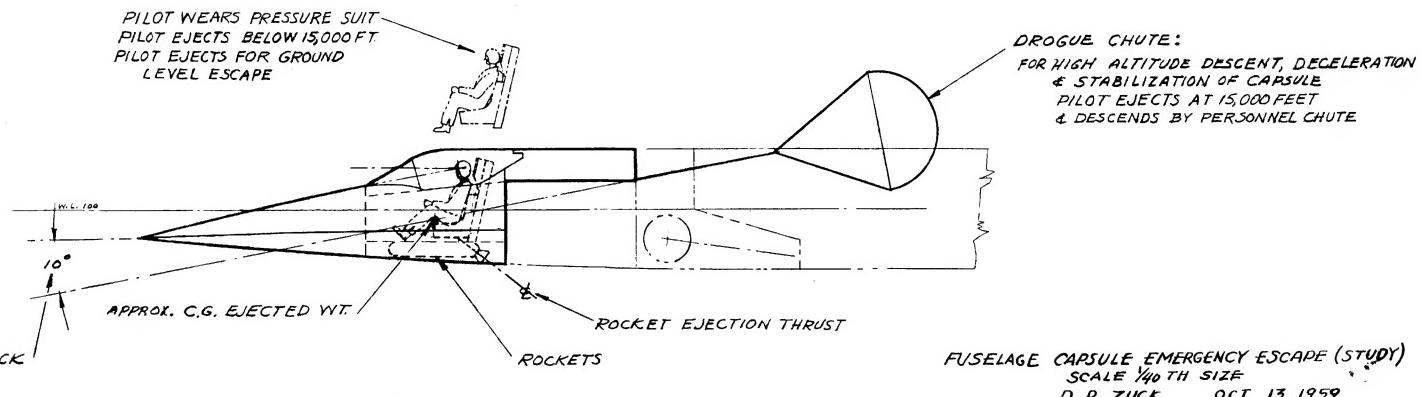
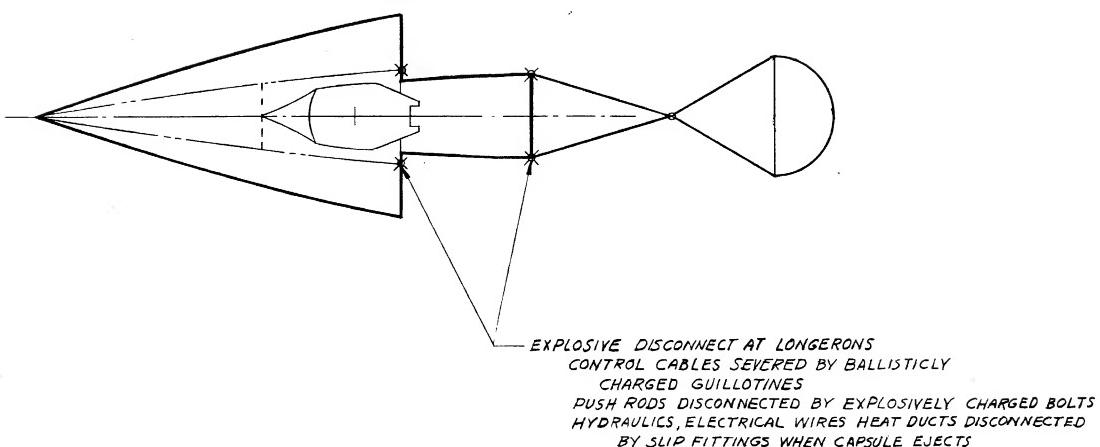
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ZERO ALTITUDE ESCAPE





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Encapsulated Seats

Since the pilot must wear a pressure suit for other reasons than escape, the encapsulated seat must be evaluated as a device to protect the pilot against wind blast during ejection.

Where ejection at very high airspeeds is necessary, a capsule appears to be required. "Very high" in this case refers to greater than 800 kts. EAS, or a dynamic pressure of greater than $2,500 \text{ lb}/\text{ft}^2$.

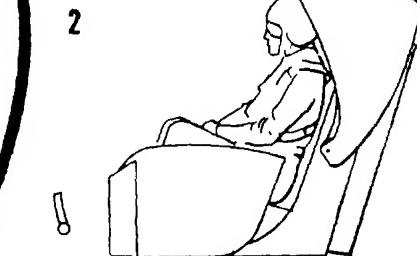
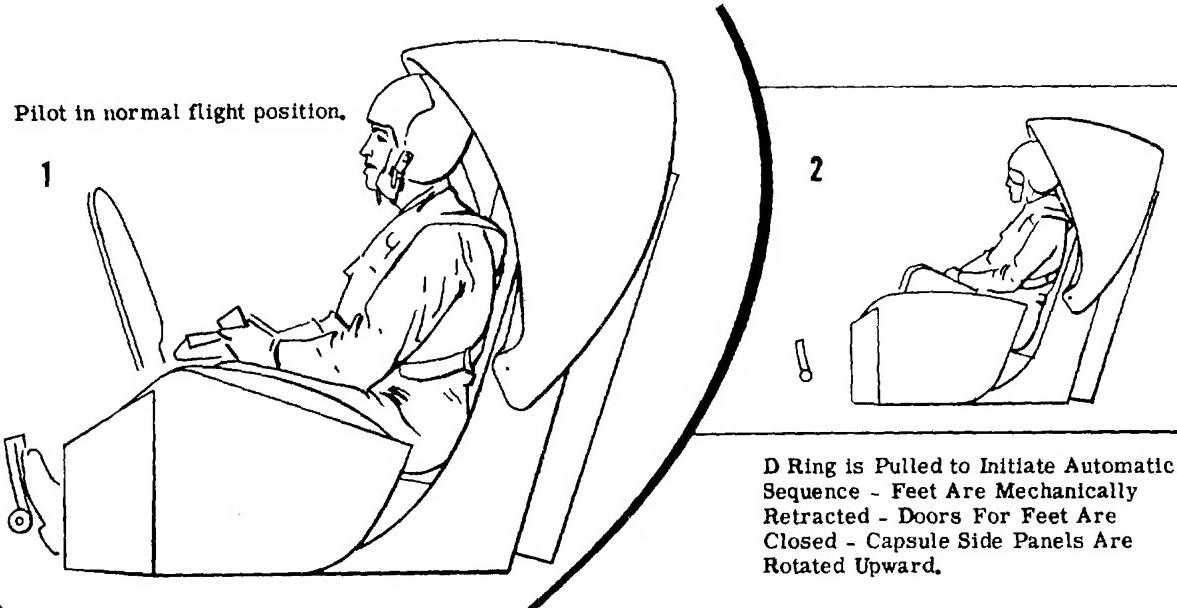
Three encapsulated seats have been studied for the A-12; the Goodyear capsule, the NAA F-108 capsule, and the Convair "B" capsule. Note that all of these are in early design or development status, and not operational.

The Goodyear capsule study has been evaluated for use in the A-12. Figures 9 through 12 show the salient features of the system, including the elaborate sequencing required. The total weight penalty for installing this capsule appears to be approximately 150 pounds, including larger parachute, rocket motor, etc.

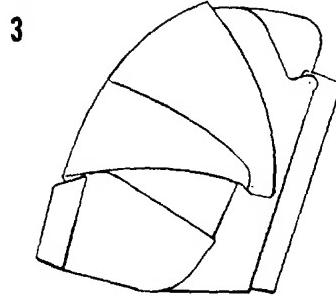
In addition to this weight penalty, a drag penalty would be incurred, since the Goodyear capsule, while the smallest of the lot, is too large to fit the A-12 cockpit. Its use would require approximately 2 ft^2 increase in fuselage frontal area, with accompanying penalty in L/D.

The NAA F-108 capsule, shown in Figure 13, is probably more realistic than the Goodyear proposal. The weight penalty involved in

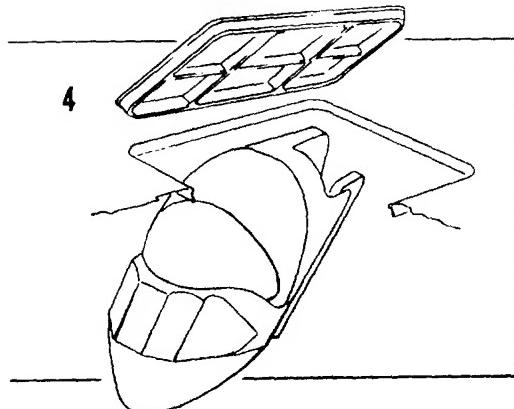
SECTION I. ANALYSIS OF THE [REDACTED] ESCAPE SYSTEM GER 8195



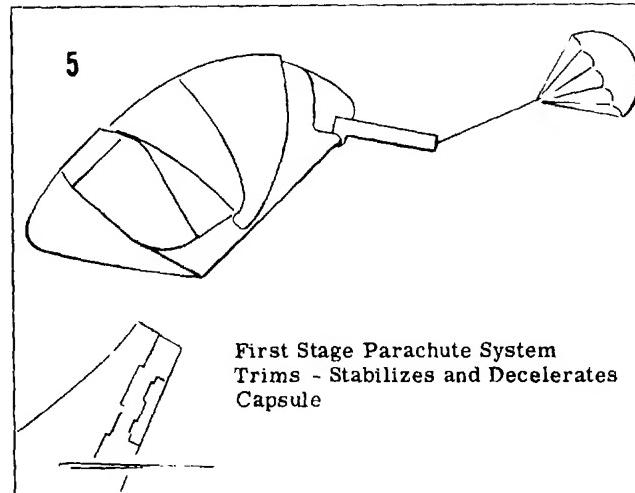
D Ring is Pulled to Initiate Automatic Sequence - Feet Are Mechanically Retracted - Doors For Feet Are Closed - Capsule Side Panels Are Rotated Upward.



Nose of Capsule is Rotated Upward -
Upper Doors are Closed and Locked -
Seals are Inflated -
Capsule is Pressurized -
Canopy is Jettisoned -
Catapult-Rocket is armed.



D Ring is Pulled Further to Initiate Capsule Ejection - Boot is Inflated - Lanyard-Gun System Forcibly Deploys Reefed First Stage Parachute



First Stage Parachute System Trims - Stabilizes and Decelerates Capsule

FIG. 9 [REDACTED] Ejection Sequence for Goodyear Aircraft Corporation Ejectable Seat Capsule

SECTION I. ANALYSIS OF THE [REDACTED] ESCAPE SYSTEM



FIG. 10
[REDACTED] Three Quarter View of Capsule in Flying Position

SECTION I. ANALYSIS OF THE [REDACTED] ESCAPE SYSTEM

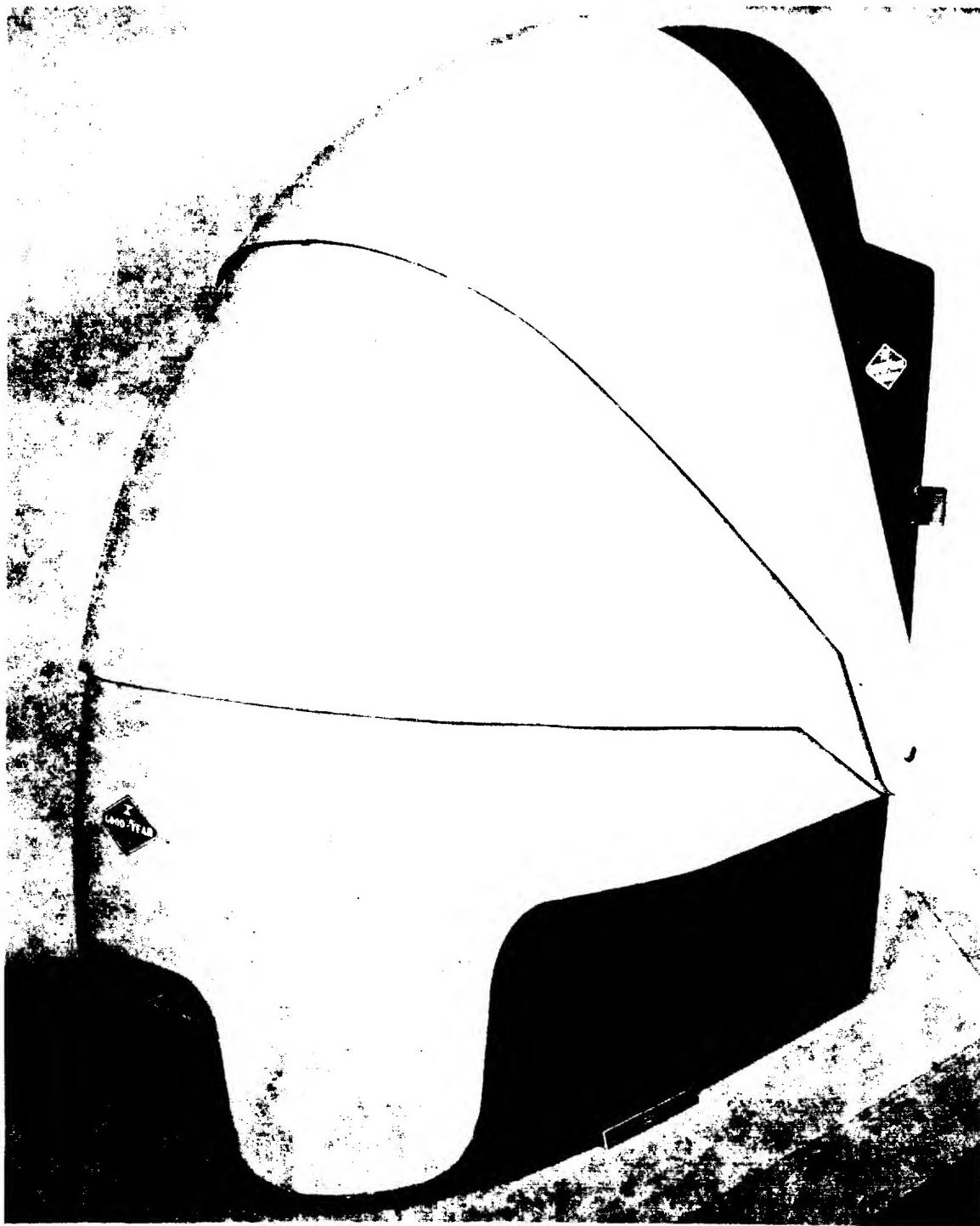
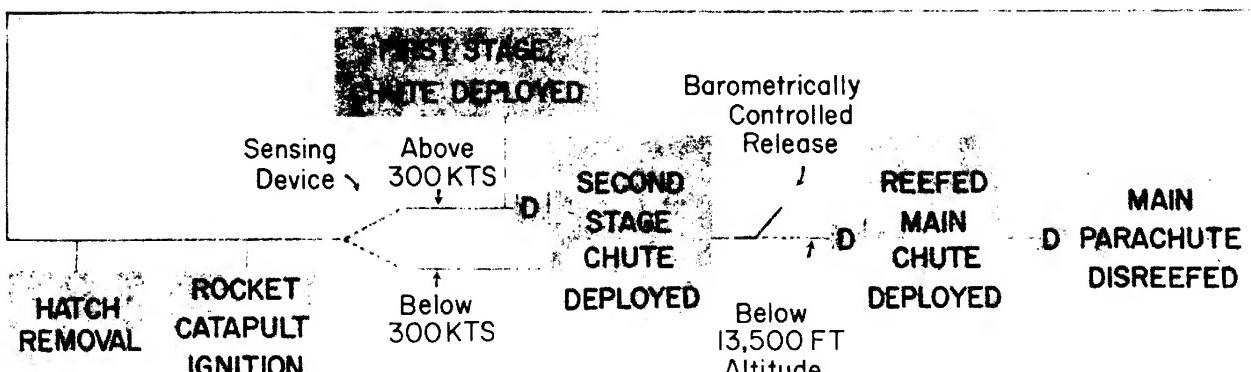
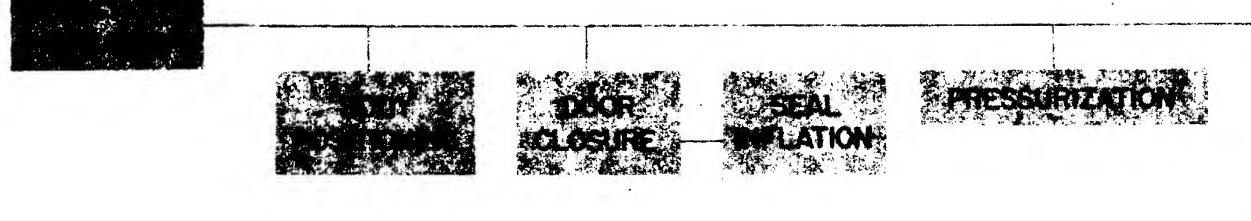


FIG. 11

[REDACTED] Three Quarter View of Capsule in Ejection Position



EJECTION SEQUENCE



D - DELAY

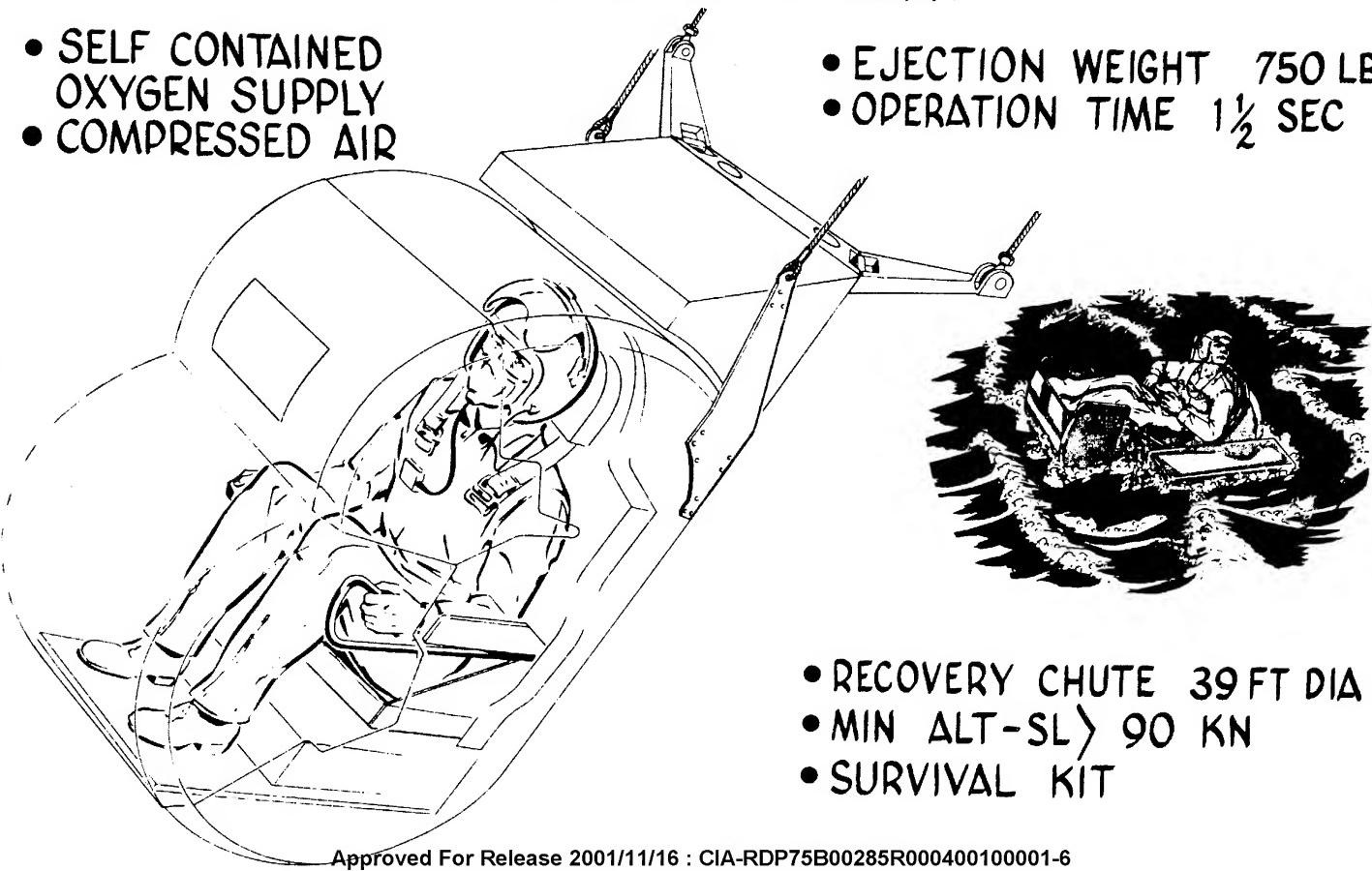
FIG. 3 - INTERCEPTING
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ESCAPE SYSTEM ENCAPSULATED SEAT

- SELF CONTAINED OXYGEN SUPPLY
- COMPRESSED AIR

- EJECTION WEIGHT 750 LB
- OPERATION TIME $1\frac{1}{2}$ SEC

FIG. 1



- RECOVERY CHUTE 39 FT DIA
- MIN ALT-SL > 90 KN
- SURVIVAL KIT

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its use is 400 pounds, and the fuselage frontal area increase required is about 3 ft². These penalties are intolerably large.

The Convair "B" seat, while not a capsule as such, has been evaluated for use in the A-12. As shown in Figures 14 to 17 , it is actually a conventional seat with displacing gear to lift it clear of the airframe before rocket firing. There are several obvious disadvantages to this arrangement:

1. The rocket acceleration is in the direction of minimum pilot tolerance; approximately 5g maximum.
2. The rocket thrust is not used to produce vertical ground clearance for zero-altitude escape.
3. The displacing gear is one more mechanism whose reliability affects the total escape system.
4. The pilot is exposed to the wind blast anyway, while being displaced to launch position.

Rocket-Catapult Seats

Since a pressure suit is required regardless of the escape system, the ideal arrangement for the A-12 is a pressure suit which can withstand the maximum dynamic pressure and temperature expected, coupled with a rocket-catapult seat for maximum zero-altitude escape capability.

The pressure suit requirement is already greatly exceeded by the MC-2 full pressure suit and MA-3 helmet which have been developed in support of the X-15 program. This suit-helmet combination has been

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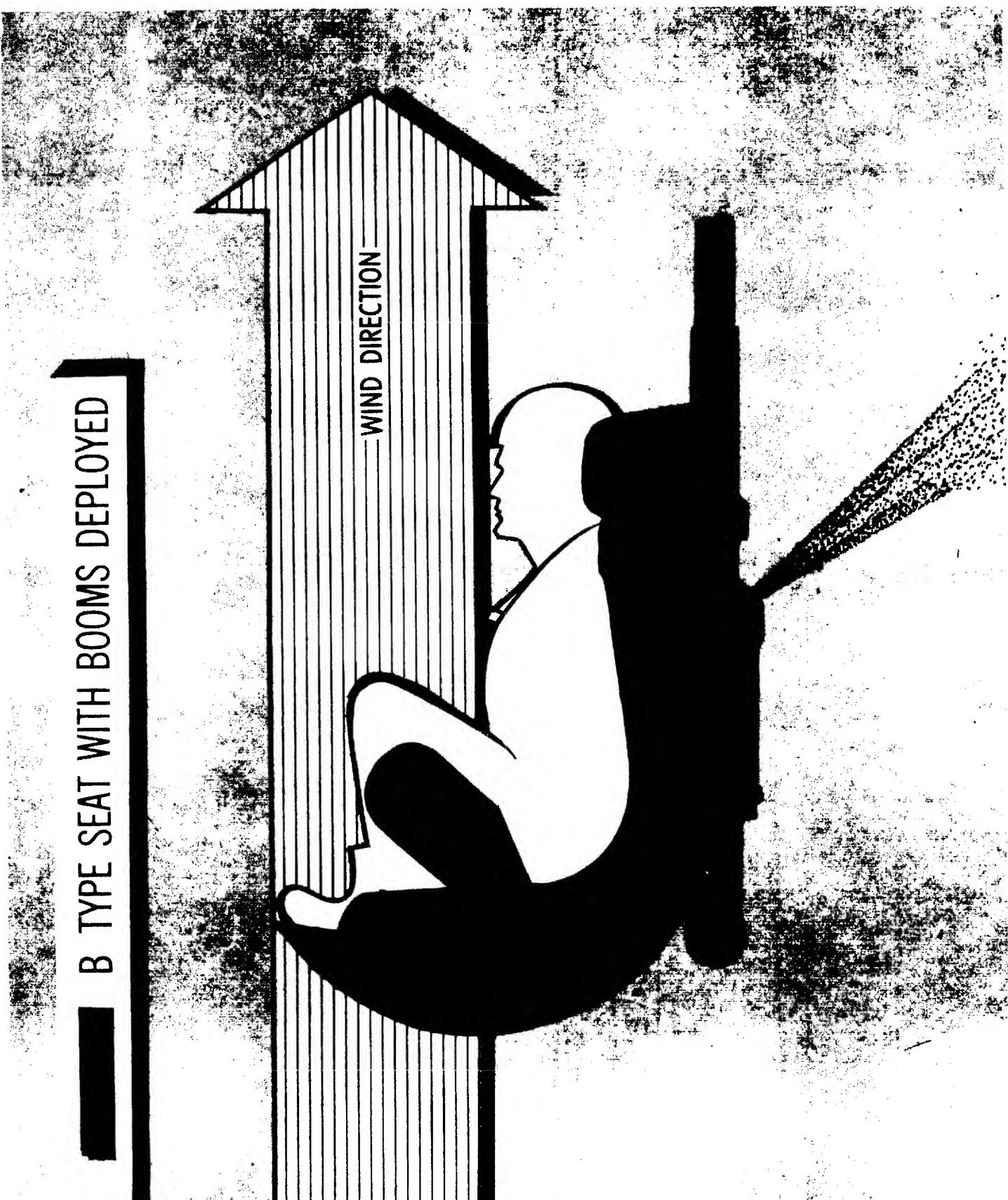


Fig. L4

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PRE-EJECTION POSITIONING OF
PILOT BY THE SEAT

B TYPE SEAT WITH BOOMS DEPLOYED

FIN CLEARANCE AT 735 KNOTS (S.L.)

ACTUAL SLED RUN TRAJECTORY

MACH 1.118 (SEA LEVEL EQUIV.)

0.401 SEC.

▲ C.G. of SEAT
• LOW POINT (BOOM)

0.308 SEC.

WL 44.80 0.208 SEC.
0.159 SEC.

STA. 158.50

WL 0.00

50

HORIZONTAL DISTANCE - FT.

30
20
10
0
VERTICAL DISTANCE - FT.

FIG. 17

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sled tested to dynamic pressures of $2,100 \text{ lb}/\text{ft}^2$; approximately 3 times the maximum pressure of the A-12. The MC-2 suit also includes a ventilation garment and heat reflecting outer garment to increase pilot comfort during normal operation, and to reduce the effects of aerodynamic heating during high-speed ejection. Figure 18 shows this suit.

Since this suit-helmet is used on the X-15 program, it is of interest to compare the mission speeds, altitudes, and Mach numbers of the X-15 with the A-12. Figure 19 shows the X-15 flight envelope, with the A-12 maximum q point noted. It is apparent that the X-15 requirements are much the higher.

Figure 20 shows a time history of a typical X-15 mission with Mach number, altitude and velocity as time functions. For comparison, the A-12 altitude and Mach number are also shown. Obviously, the X-15 escape problem is a great deal more severe than that of the A-12.

It is apparent that with a suitable pressure suit, which the MC-2 is, no case can be made for fuselage nose capsules or encapsulated seats. The maximum pilot safety will be achieved by the use of this suit in combination with a rocket catapult seat to give the greatest possible zero-altitude escape capability.

Several rocket-catapult seats have been evaluated for the A-12. Those include the Martin-Baker seat, the NAA seat as used on the X-15, and the Lockheed C-2 seat as used on the upward ejection F-104.

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X-15 MISSION

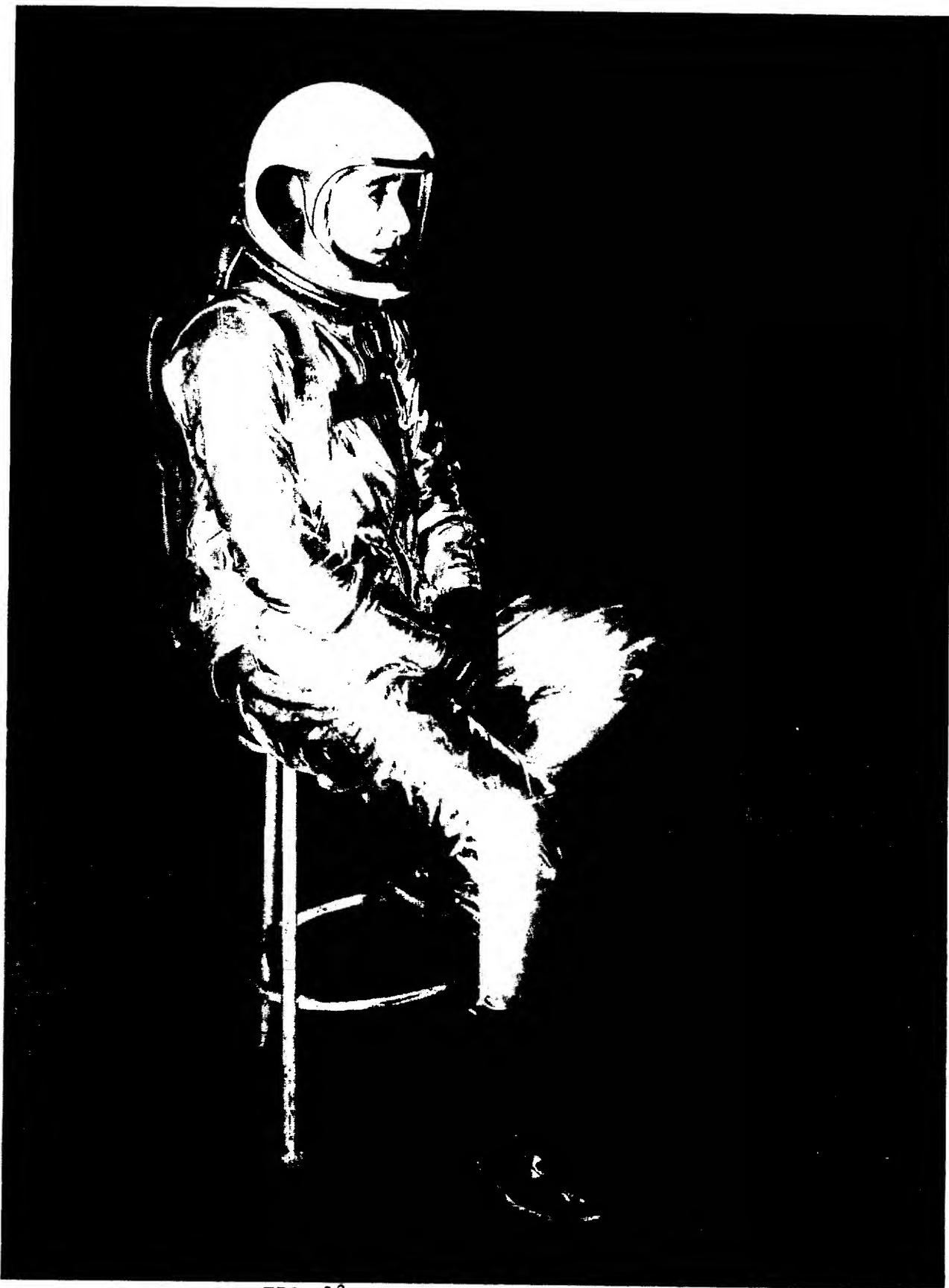
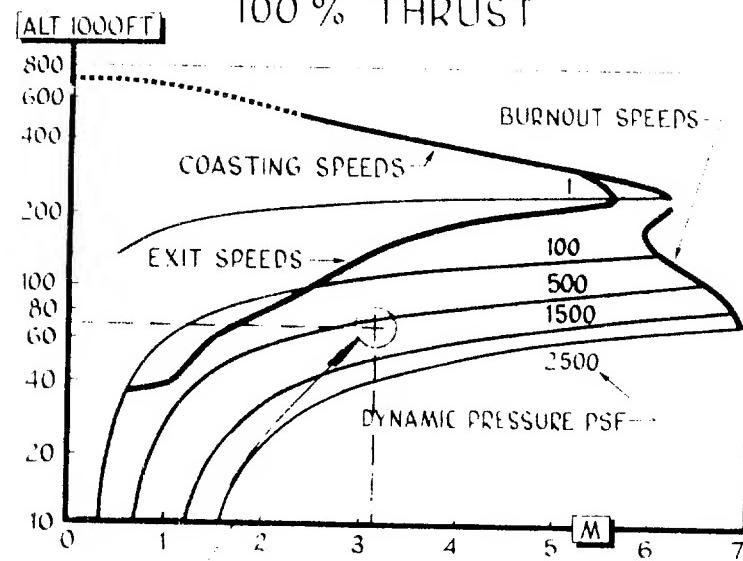


FIG. 18

MC-2 FULL PRESSURE SUIT
MA-3 HELMET (MODIFIED)

SAC RMP

X-15 MISSION
FLIGHT ENVELOPE
100 % THRUST



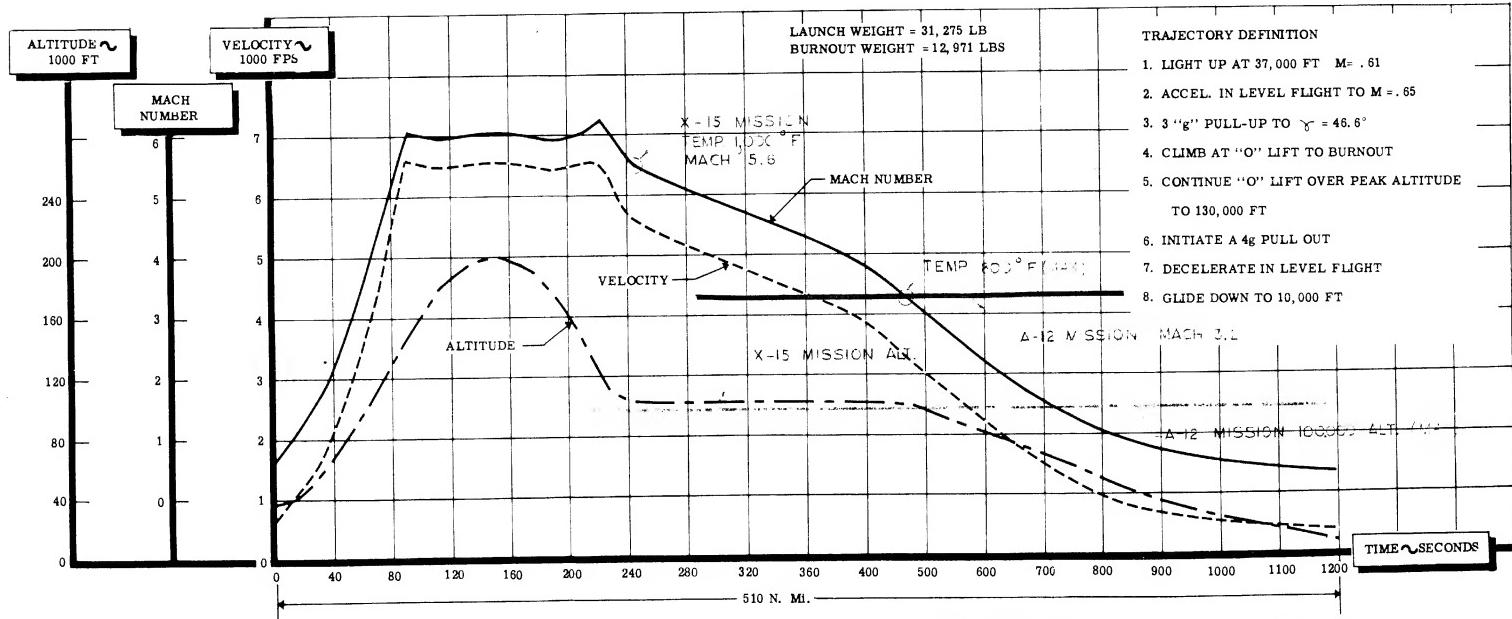
A-12

MISSION 542 PSF (MAX.)
EAS 400 KNOTS

[REDACTED]

MACH. 3.2

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TRAJECTORY OF THE X-15 RESEARCH AIRPLANE
TYPICAL SPEED MISSION

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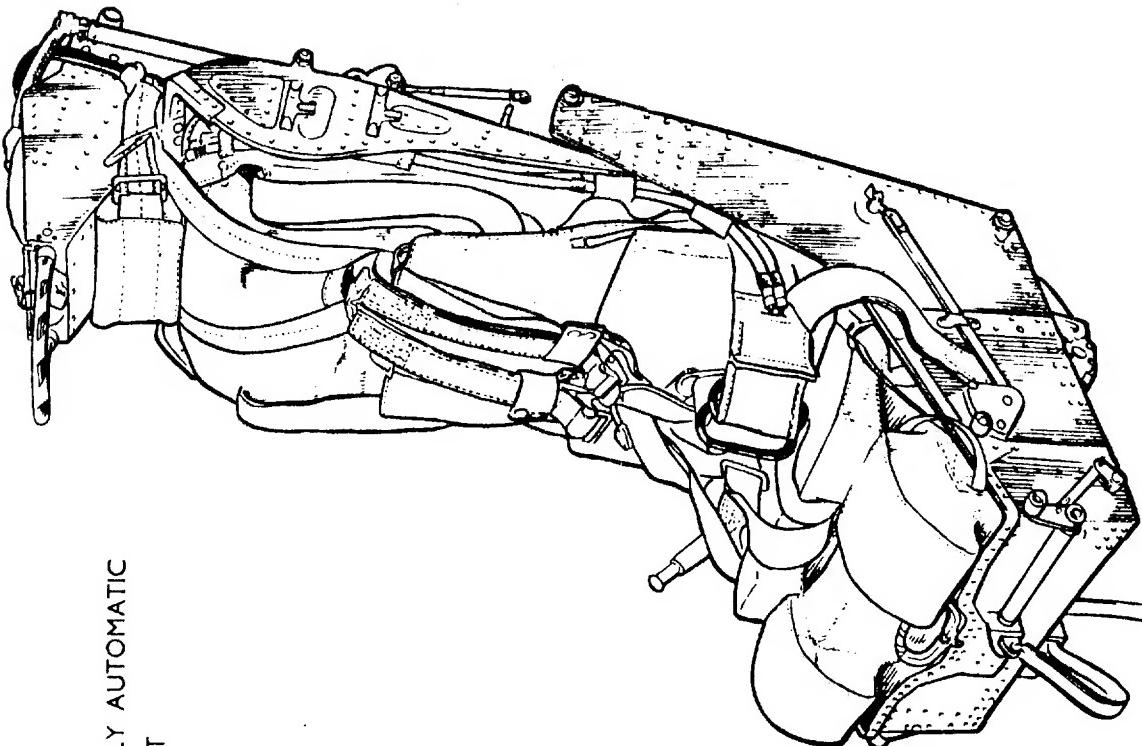
The Martin-Baker seat has a number of attractive features, as follows: (Fig 21 through Fig. 23)

1. It has a drogue gun which deploys the drogue chute and the main canopy, thereby insuring reliable and instantaneous opening of the chute.
2. The seat is stabilized by a drogue chute, and the man rides the stabilized seat down from high altitude to 15,000-10,000 feet before he is automatically separated from the seat. The seat is not roll stabilized.
3. The seat has a ground adjustable force limiter which delays seat-man separation until deceleration has decayed to the 6 to 4 G limit for which it has been set.

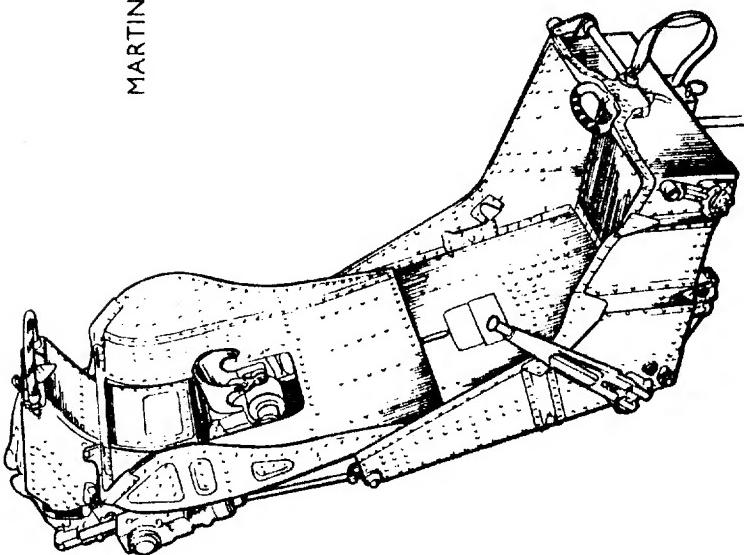
The disadvantages of Martin-Baker seat are:

1. The complete package, chute, seat, rocket, harness, reel, survival kit, etc., are integrated with the seat and furnished by Martin-Baker. This creates critical security problems and development liaison problems since Martin-Baker production and engineering are in England. Intolerable inconvenience and increased development time will result from using the Martin-Baker seat in the A-12 airplane.

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MARTIN-BAKER Mk. AS FULLY AUTOMATIC
EJECTION SEAT



RIGHT HAND AND LEFT HAND VIEWS OF SEAT

MARTIN BAKER



OCCUPANT IN EJECTION POSITION

ACTION 3—Pull the firing handle smartly downwards, drawing the face screen over the face, thereby commencing the ejection sequence.

65. The firing control is designed to ensure that the face is protected by the face screen before the charge is fired; it is therefore necessary to pull the firing handle right down to the fullest extent. Only in cases where it is impossible to reach the blind firing handle should the alternative firing handle be used.

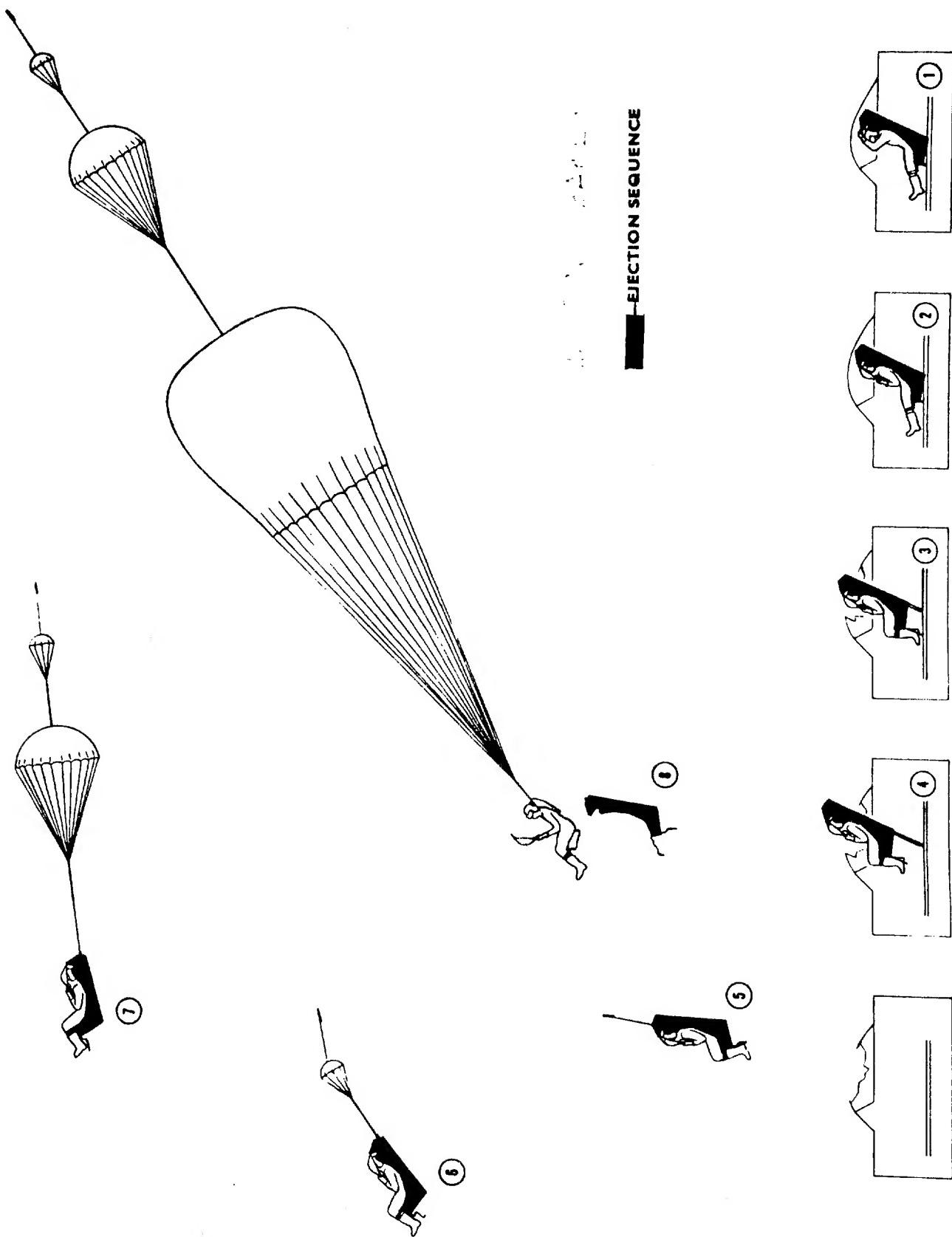
Sequence of operations, Figure 18

66. On pulling the firing handle a cable attached to the face screen extracts the wedge shaped sear from the ejection gun firing head thereby firing the main charge and immediately ejecting the seat and occupant from the aircraft.

67. Upon ejection the leg restraint cord tightens up between the snubbing unit and leg line lock in the seat pan automatically securing the occupant's legs to the front face of the seat pan, where they are firmly held until the harness is released and the occupant is separated from the seat.

68. Also on ejection two trip rods attached to the bulkhead withdraw sears setting off the drogue gun and time delay mechanisms.

69. One half second after ejection the drogue gun piston is fired and extracts the controller drogue. This drogue in turn extracts the main drogue which draws with it a nylon cord attached to a scissor shackle on top of the seat. The drogues, when developed, retard, stabilize and put the seat into convenient attitude for separation.



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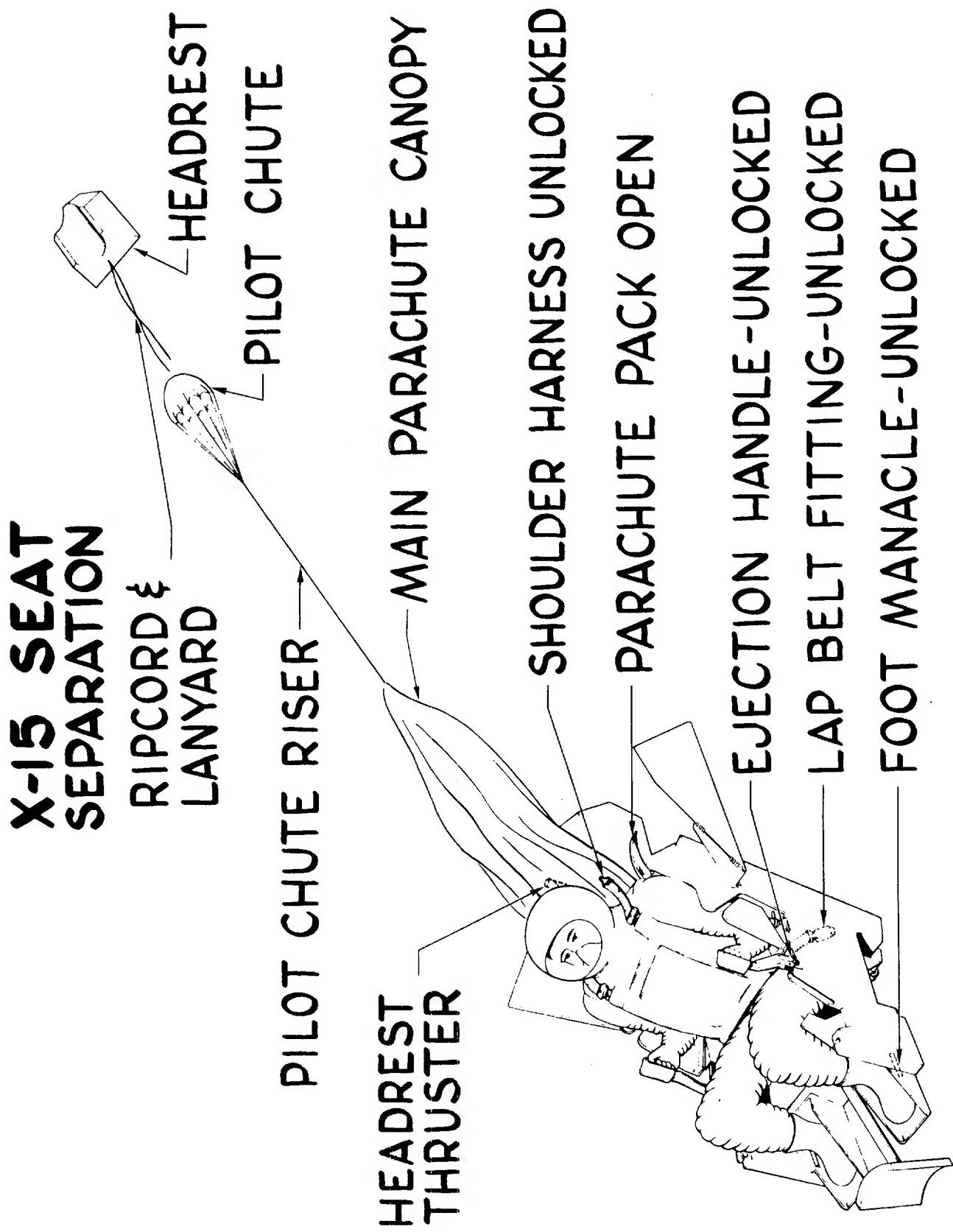
2. The Martin-Baker seats are marginal in ground level escape capability with the present ejected weights. The Navy contractors are exceeding the original seat-man design weights by approximately 30 pounds. This reduces the height of the trajectory to a marginal level.
3. The Martin-Baker parachute is 24 feet in diameter, which is marginal for a heavy man with full survival equipment.
4. Due to off-center application of the catapult ejection force, the seat-man, upon leaving the cockpit, begins a counterclockwise rotation which is later arrested by the drogue chute. This introduces the possibility of chute fouling and chute deployment delay.

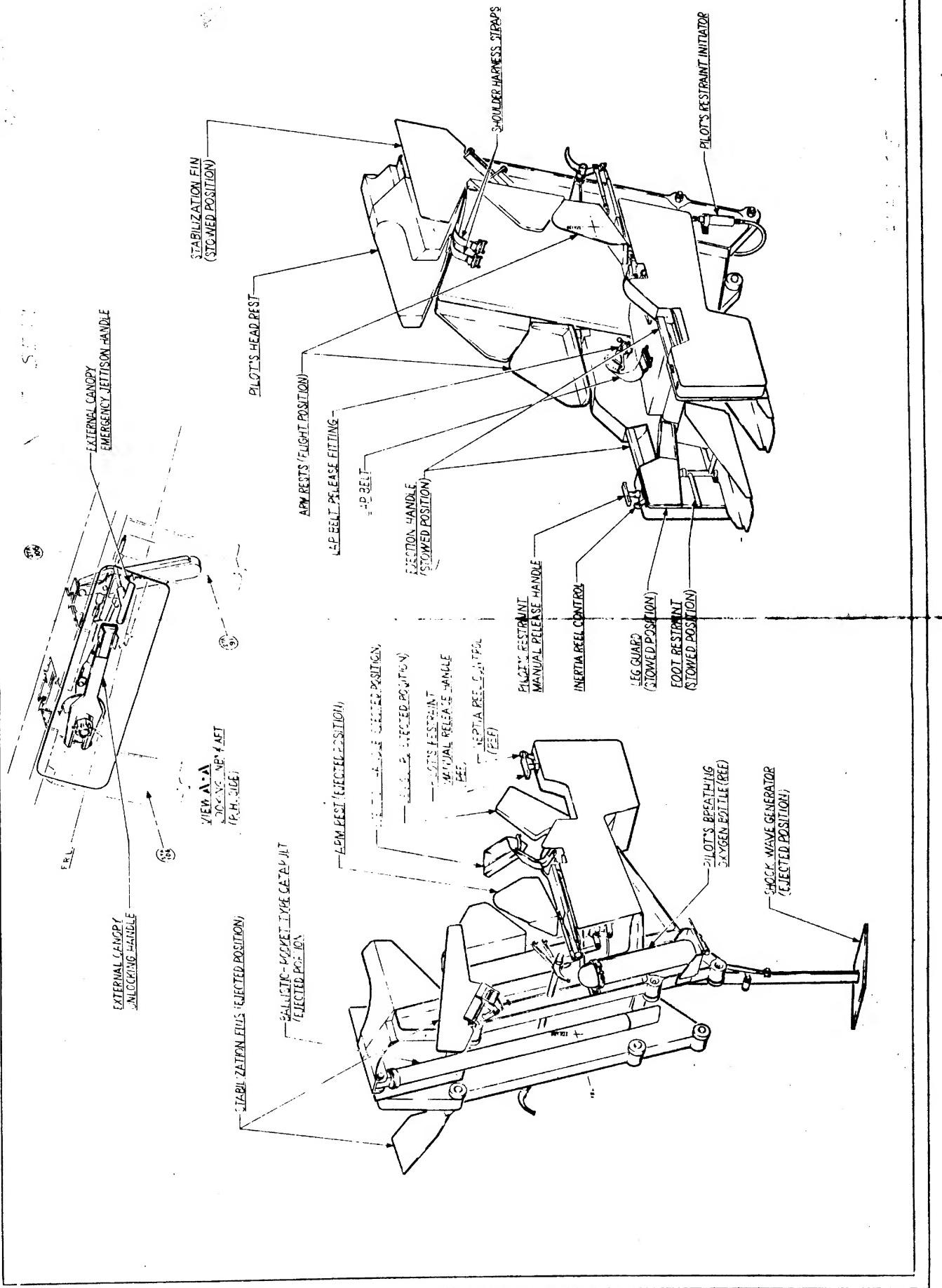
The NAA seat as used on the X-15 is shown in Figures 24 and 25. It is a rocket catapult seat with stabilizing fins and a skip-flow generator for reducing air blast on the pilot under the extreme dynamic pressure experienced in X-15 ejection.

The pilot rides the seat down to 15,000 feet at which time he separates from the seat.

This seat is quite similar to the downward ejection "D" seat as developed by Lockheed under Air Force contract. This seat also has stabilizing fins and a skip-flow generator, and is designed for 800 kts. EAS. This, of course, is three times the q of the A-12.

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The seat which appears best for the A-12 is the Lockheed C-2 seat as used on the upward-ejection F-104. Its ground level escape capability has been demonstrated by sled tests from 120 kts. to 420 kts., and is believed adequate at 90 kts. See Fig. 26 through 29

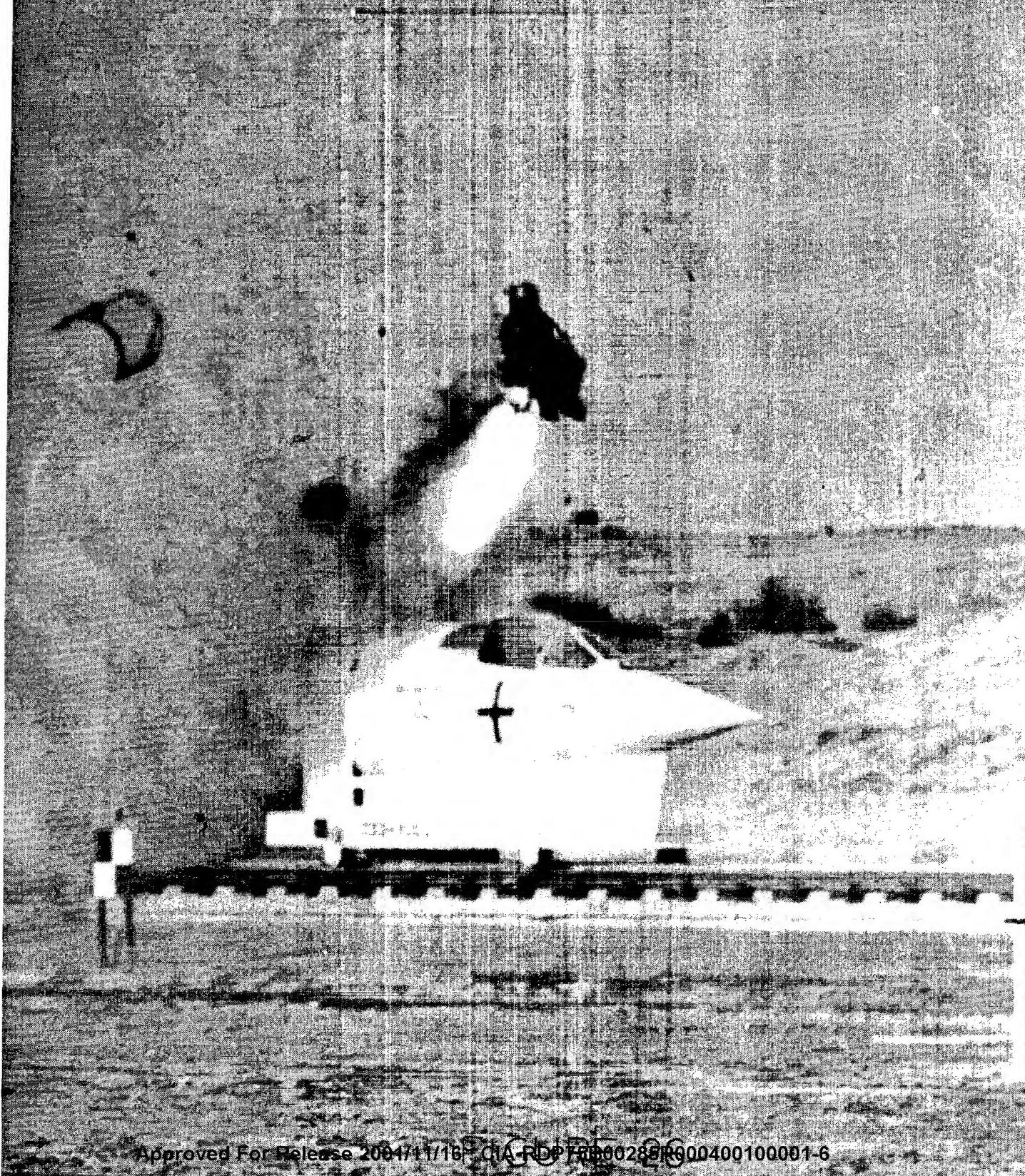
This seat is equipped with the Frankfort Arsenal XM-10 rocket-catapult, and achieves a rise in static firing of 230 feet.

As used on the F-104, the seat employs the "one and one" system (one second seat separation and one second parachute deployment). This system is satisfactory for both low and high altitude escape. Some consideration is being given by the F-104 project to a modification to this system (for the Canadian F-104s) which would equip the belt initiators with an aneroid to prevent man-seat separation until 15,000 foot altitude. It should be noted that the USAF prefers the present system for the standard F-104s because of the low frequency of high-altitude ejections on the Century series fighters and other supersonic aircraft.

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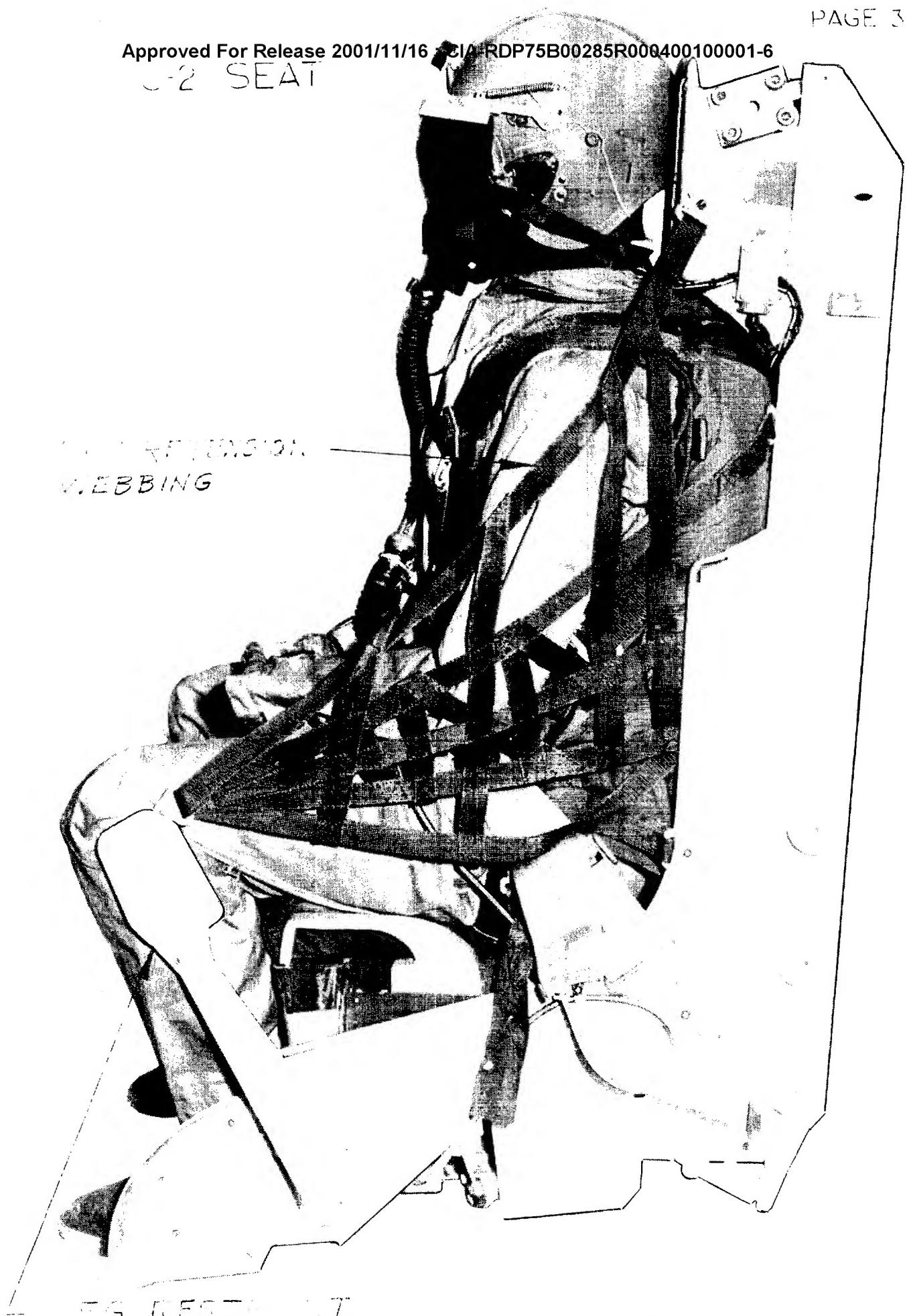
C-2 ROCKET CATAPULT EJECTION SEAT



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-2 SEAT

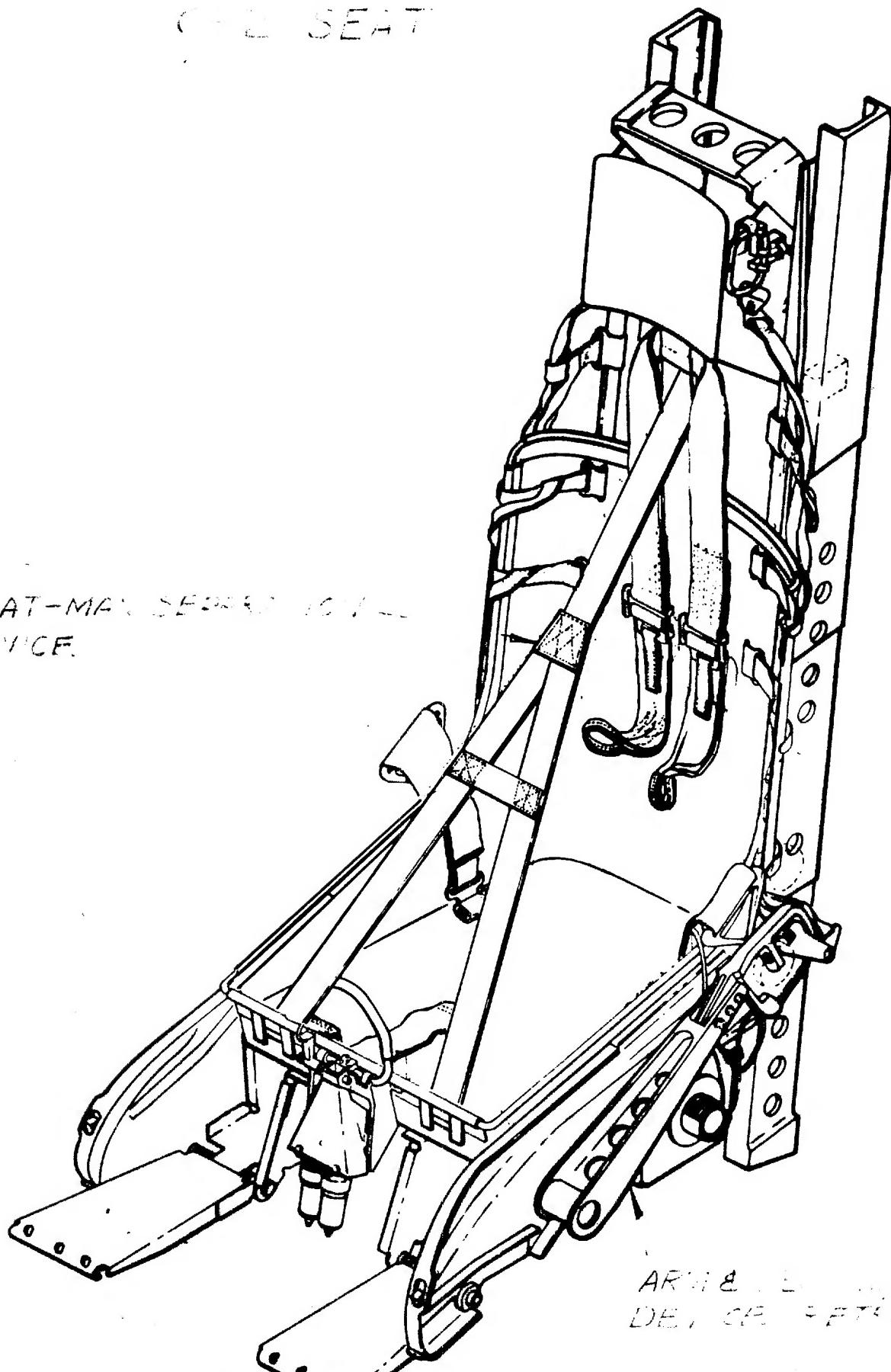


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CO-2 SEAT

SEAT-MAN SEPARATION
DEVICE.

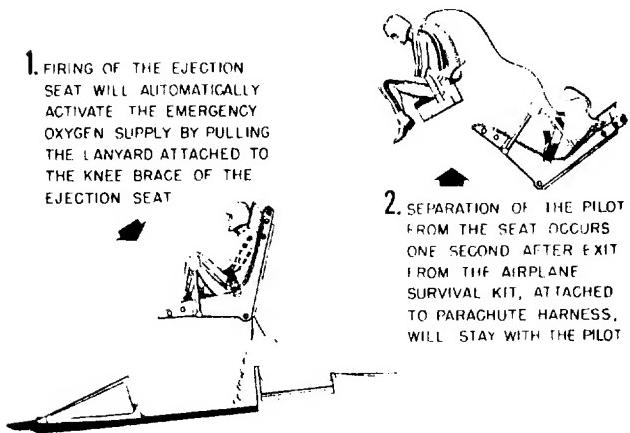


ARMED BY PYROTECHNIC
DEVICE - SEPARATE

FIGURE 28

SEAT

SEAT EJECTION & SEPARATION



DESCENT AND KIT DEPLOYMENT

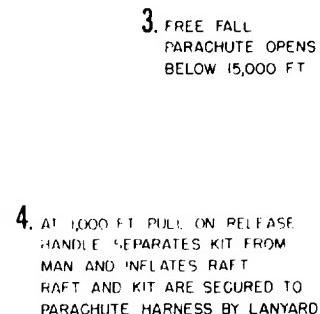


Fig. 15 Escape and Survival Sequence

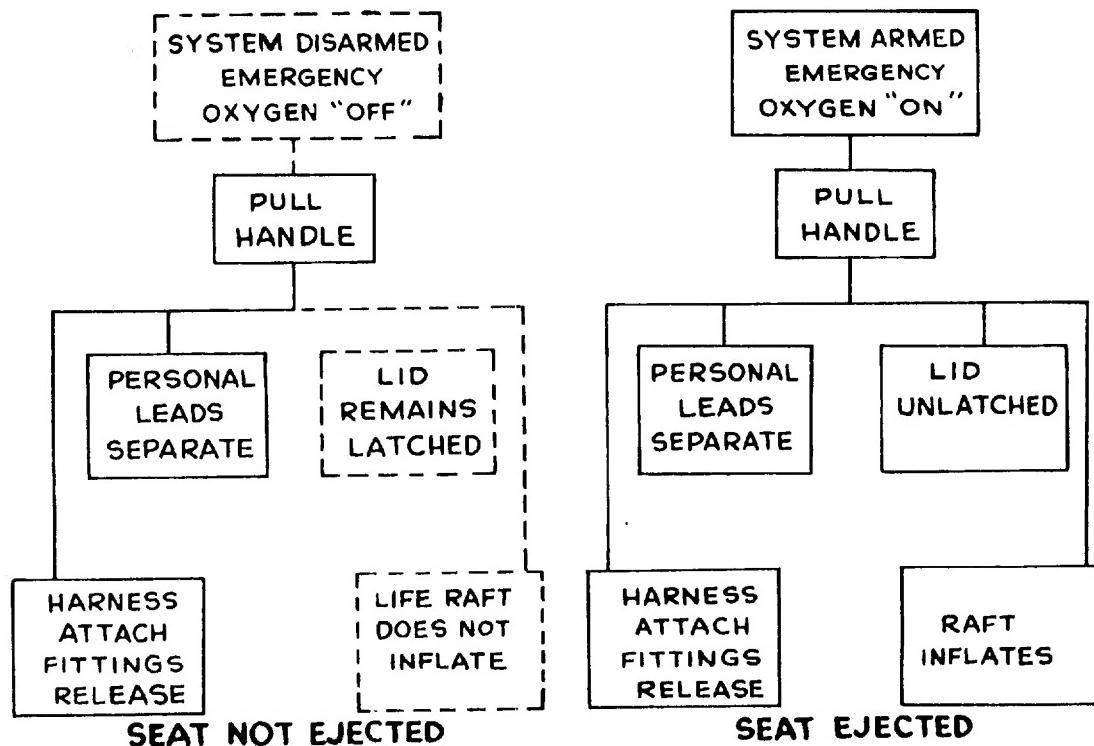


FIG. 29

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CONCLUSIONS

The maximum safety of the pilot of the A-12 will be achieved by the use of the following escape system:

1. The David Clark MC-2 full pressure suit, with MA-3 helmet.
2. The Lockheed C-2 seat, as used on the F-104.
3. The B-5 parachute pack.

All of the above components have a demonstrated capability greater than required for the A-12. The escape system complexity is minimum, and therefore the likelihood of malfunction is minimum.

It should be emphasized that the pressure suit is not merely preferred to the encapsulated seat, but is a requirement in its own right to protect the pilot against loss of cockpit pressure. This type emergency is much more common than that requiring ejection.

The use of a fuselage nose capsule or seat capsule will cause a weight penalty of 150-1,500 pounds and, in the case of seat capsules, a drag penalty resulting from the increased cockpit room required. Any of these systems are more complex, and therefore more subject to malfunction.

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ANALYSIS OF A12 ESCAPE SYSTEM

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